THE LABOUR MARKET IMPACTS OF HIGH TECHNOLOGY: IMPLICATIONS FOR THE UNIVERSITIES

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The opinions expressed in this report are the author's and not necessarily those of the Council of Ontario Universities

November 1983

SUMMARY

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The Canada Tomorrow Conference recently sponsored in Ottawa by the Ministry of State for Science and Technology highlighted concerns about the economic and employment impacts of microcomputers, robotics, CAD/CAM and the other equipment and processes in the loosely-defined category of "high technology". Despite numerous studies and a range of predictions, there is no clear consensus on the long-term employment outcomes of technological change.

Conventional employment projection methods do not adequately deal with the rapid changes in job requirements that arise from new high technology industries and processes. It may also be misleading to extrapolate the experiences of particular sectors or categories of workers to the larger economy. There is more agreement on the direction of trends than on the number of jobs that will ultimately be affected. Whether the total impact of new technologies is seen as negative or positive, it is generally agreed that to resist implementation would be more harmful to a nation's economy than whole-scale adoption.

Historical trends in industrialized countries show a gradual shift in employment from agriculture and industry to services. While the service sector (especially clerical and managerial work) has the most potential for future employment growth, it will also be most severely affected by information technology.

Pessimists expect that not only will the number of jobs lost exceed the number created, but that in addition, many of the jobs that remain will

have reduced skill requirements, rather than demanding higher levels of quantitative or technical expertise. Those who predict a more optimistic outcome tend to focus on the longer term, when the benefits of high technology will be more apparent than the short-term disruptions. Although some jobs will be lost, they will be compensated for by new jobs in new industries and applications, and by the improved quality of the remaining jobs. The optimistic scenario is supported by historical evidence of earlier changes in technology, such as the introduction of computers in the fifties and sixties, and the earlier mechanization of agriculture.

Analysts who have examined evidence for both the optimistic and pessimistic scenarios remark on the lack of convincing quantitative analysis of the overall impact of changing technology. Although the long-term outlook is uncertain, there is still a need for continuing research, and for measures to ease the transition for those categories of workers who will certainly be affected: women, low- and medium- skill workers in manufacturing, and certain categories of middle-level managers.

Recurrent education and retraining are obvious solutions to anticipated structural employment problems. However, if the long-term scenario of the pessimists is realized, the problem will not simply be one of skill mismatches, but of sharing a limited number of jobs among a large number of potential workers, most of whom might be very well-qualified by any standard. We will need to change our attitudes toward work, if, with the aid of machines, fewer workers are able to produce all the goods and services that the economy requires. Measures to share the existing

work will have to be considered, and education for leisure may become as important as advanced technical and scientific education.

The provision of highly qualified personnel is the universities' most obvious role in a technological society. It is clear that the good jobs of the future will require more scientific knowledge and higher technical skills, and that economic growth based on technological advances depends on having adequate numbers of workers with the right skills ready at the right time. However, it is less certain that this kind of training is required of the entire labour force.

Citing estimates of occupational growth produced by the U.S. Department of Labor's Bureau of Labor Statistics, some analysts and commentators are questioning the assumption that more scientific and technical training is required for the entire labour force. Although between 1978 and 1990, the projected fastest growing job categories in terms of percentage change include several high technology areas such as data-processing-machine mechanics, computer systems analysts, and computer operators, the total number of new jobs generated in these and other high technology occupations will be vastly outweighed by employment growth in other areas. The five occupations expected to produce the most new jobs are all in low skilled areas: janitors, nurses' aides, sales clerks, cashiers, and waiters and waitresses.

The possible emergence of a bimodal labour market, with a few high-skill jobs at the top, many low-skill ones at the bottom and very few in the middle has serious implications for educational planning. There is already evidence that traditional middle-level jobs in manufacturing and business will be highly susceptible to displacement or deskilling

because of the introduction of robotics and various information technologies. Programmes for retraining will have to concentrate on generic skills, with emphasis on the ability to adapt and learn, rather than on narrow occupation-specific training. The equitable distribution of technological gains may be a growing problem for industrial economies, and one which could require more public sector involvement.

Given the uncertainties about the economic and societal impacts of changing technology, the universities have several identifiable responsibilities. First of all, more research is needed on the long-term impacts of microelectronics and other technologies, including identifying more clearly the characteristics of new jobs, and the directions in which existing jobs will change.

Research is also needed on the broader societal impacts. The whole question of sharing the benefits and costs of technology needs to be considered. Input should come from a number of disciplines: psychology, sociology, public administration and law, as well as economics and education.

In terms of their educational function, universities have a clear role in preparing highly-qualified personnel. University participation rates may increase, and there will certainly be more demand for engineering and scientific education. The provision of computer and numeracy skills for all graduates will be increasingly important. There may also be renewed interest in general analytical, communications and learning skills. However, it is impossible to predict whether this emphasis on the general rather than the narrowly job specific will point to improved employment prospects for the liberal arts graduate.

Attention is also being given to skill development and recurrent education for adults. Colleges have generally been seen as more flexible than the universities in providing for the educational and training needs of non-traditional students. As retraining and upgrading become increasingly important, universities must be ready to meet changing demands. This may include offering short-term courses to update the skills of professionals who are already employed, as well as making regular programmes at all levels more accessible to part-time and mature students.

As providers of highly-qualified personnel and as centres for technical and scientific research, universities will continue to be key resources in an information-based society, whatever the long-term consequences of technological change. It is essential, however, that we maintain a broad perspective on change, and not be forced (or enticed) into narrow roles or short-term reactions.

INTRODUCTION

Governments, educational institutions and the general public are becoming increasingly concerned about the economic and employment impacts of microcomputers, robotics, CAD/CAM* and the other equipment and processes in the loosely-defined category of "high technology". We are constantly seeing predictions of technology's potential for creating or displacing jobs. While several reviews of current research have been published, a clear consensus on the long-term employment outcomes continues to elude us. This paper draws on some major studies of high technology and its labour market impacts, and identifies issues of most immediate concern to universities. Although information on the subject is often tentative and anecdotal, universities need to be familiar with both the speculations that may influence public opinion and policy, and with the more empirically verifiable economic impacts of technological change. Governments at all levels are emphasizing the contribution of high technology industries to economic growth, and as a consequence, are increasingly inclined to tie support for postsecondary education more closely to the provision of appropriate research and manpower.

*Computer Aided Design/Computer Aided Manufacturing

1.0 PREDICTING THE EMPLOYMENT IMPACTS OF TECHNOLOGICAL CHANGE

The ability to accurately forecast the long-term impact of technological change on net labour requirements is limited. Conventional projection models rely on historical data to derive both the mix of occupations within industries and the skill requirements for occupations, and thus do not adequately reflect rapid change within particular occupations or sectors.[1] On the other hand, the experiences of individual industries or categories of workers cannot simply be extrapolated to the larger economy, as has been done in some of the more dramatic estimates of job loss, deskilling and job displacement. Interactions between sectors, relative costs of equipment and labour, and impediments to the diffusion of new technology need to be considered as well.

There is more agreement on the direction of trends than on the number of jobs that will ultimately be affected by new technologies and their application. Whether the total impact is seen as negative or positive depends on perspective and the anticipated time-frame for change. It is expected that the widespread introduction of microelectronics in industry and in the service sector will result in some structural unemployment in the short to medium term, but in the long term, the net employment impact is uncertain. Optimists and pessimists differ in their estimates of the total number of jobs that will be created or

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[1] For a more detailed discussion, see Laura Selleck, "Manpower Planning and Higher Education Policy", Council of Ontario Universities Research Report (Toronto, June 1982).

destroyed, in their assessments of the quality of jobs retained or newly created, and in their expectations of the speed of transformation and thus the capacity of existing policies and institutions to adapt to inevitable change. However, few suggest that it is practical to forego the implementation of new technology because of possible job loss. To resist advances in information technology and its applications would be more harmful to a nation's economy than whole-scale adoption, as has been estimated for the United Kingdom in a frequently cited report from the pessimistic side:

> **Remain as we are, reject the new technologies and we face unemployment of up to 5.5 million by the end of the century. Embrace the new technologies, accept the challenge and we end up with unemployment of about 5 million.** Whilst there is a world of difference between the two consequences and the possibilities that can be exploited inherent in these strategies, the latter is by far the most favourable. What is clear is that whichever road we take work will collapse.[2]

Or, in the words of Nobel Laureate Wassily Leontief, director of New York University's Institute for Economic Analysis:

> The computer and the robot are already beginning to replace the simpler mental functions of blue- and white-collar workers. Man, as a factor of production, has only two aspects: physical and mental. Both are being replaced. The only solution is to stretch out vacations, shorten work hours and share available jobs. Human workers will go the way of the horse.[3]

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[2]Clive Jenkins and Barry Sherman, The Collapse of Work (London, 1979), p. 113.

[3]Time, 30 May 1983, p. 62.

2.0 HISTORICAL TRENDS AND RECENT EXPERIENCE

Juan Rada, in a report for the International Labour Organization[4], reviews the historical and projected effects of technological change on the economies of both developed and developing countries. He places expected changes resulting from information technology within the larger context of shifts in employment from agriculture and industry to services in industrialized countries. These historical trends indicate that the service sector (especially clerical and managerial work) has the most potential for future employment growth. However, it is the service sector which will be most severely affected by information technology. The creation of new industries may also not be sufficient to compensate for lost jobs, since most of the products and processes to which microelectronics are applied are labour-saving. On the other hand, the need for extensive retraining, and problems produced by higher unemployment and increased leisure time may produce more jobs in education and the social services. While Rada outlines these and other potential means of job creation, he believes that longer term trends point to net job loss, which will require fundamental changes in attitudes toward work as society no longer needs to make full-time use of its entire potential labour force (p. 84).

Pessimists expect that not only will the number of jobs lost exceed the number created, but that in addition, many of the jobs that remain will

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[4]The Impact of Micro-electronics: A Tentative Appraisal of Information Technology (Geneva, 1980).

have reduced skill requirements, rather than demanding higher levels of quantitative or technical expertise. Women, who have traditionally been employed in clerical and service jobs; low- and medium- skill workers in manufacturing; and certain categories of middle-level managers will be most severely affected. The kinds of jobs that are likely to be automated tend to involve repetitive work without decision-making responsibility; support work rather than work exercising control and initiative; work consisting of reporting and recording, monitoring, supervising, orchestrating procedures and scheduling work and people; and work where judgment has been replaced by reliance on logic and statistical analysis.[5]

Microtechnology has already produced massive changes in clerical jobs, as is documented in Canadian studies of both private and public sector offices. Heather Menzies uses case studies of four business sectors (insurance, banking, supermarkets and telephone exchanges) in an examination of the impact of microtechnology on clerical jobs. Different assumptions about the speed of technology diffusion, productivity, and female labour-force participation rates are combined in four alternative projections that indicate serious displacement of clerical workers in the years ahead. Menzies projects that even under the most benign of the scenarios, the unemployment rate among female clerical workers would nearly double by 1990.[6]

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[5]Heather Menzies, Computers on the Job: Surviving Canada's Microcomputer Revolution (Toronto, 1982), p. 119.

[6]Women and the Chip: Case Studies of the Effects of Informatics on Employment in Canada (Montreal, 1981), p. 73.

On the other hand, a study of the effects of microelectronics on employment in Ontario municipal government offices suggests that in the public sector, at least, the use of microtechnology for data and word processing applications does not inevitably lead to lower employment.[7] In the departments affected by automation, the number of employees first increased slightly, then levelled off and remained stable despite substantial increases in workload and improved turnaround time. Redundant jobs were usually eliminated by attrition or lateral transfer; overtime work, casual employment, and contracting out were reduced, but no firings of permanent employees were reported. However, there was evidence of a skills gap in financial operations as lower clerical jobs were lost through attrition, and upgraded positions were frequently filled by more highly skilled replacements from outside (p. 38).

Even Japan, an acknowledged leader in successful technological applications and harmonious labour management, has not been immune to disruptions and job displacement. According to to a recent Globe and Mail article, in the first five months of this year, 172 presidents of major companies stepped down, mainly because they were unable to cope with rapid technological changes:

> Automation by robots and microelectronics is at least partly responsible for the redundancy of large numbers of workers. Industries that once had 100 men on the assembly line now only need three to mind the robots. . . . While the theory goes that

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[7] Microelectronics and Employment in Public Administration: A Case Study in Three Ontario Municipalities (Research Branch, Ontario Ministry of Labour, September 1982).

> robots and microchips will free labor from dirty, boring jobs to seek more meaningful work in the fast expanding service and "soft economic" sector of high tech, so far the Japanese experience has been a new loss of jobs hidden by attrition or transfer to do-nothing jobs.[8]

Those who predict a more optimistic outcome tend to focus on the longer term, when the benefits of high technology will be more apparent than the short-term disruptions. They predict that higher productivity will generate new wealth that can be invested in labour-producing enterprises, as well as shorter hours; increased opportunity for leisure-time activities (which will mean more employment); and the substitution of machines for men and women in tedious, repetitive and dangerous jobs. Although some jobs will be lost, they will be compensated for by new jobs in new industries and applications, and by the improved quality of the remaining jobs. The optimistic scenario is supported by historical evidence of earlier changes in technology, which were often expected to to create massive unemployment. Instead, new technologies created jobs and greater prosperity. For example, the installation of computers during the 1960s and 1970s was accompanied by a substantial growth in the number of clerical jobs, and a 25 per cent increase in their share of the total job market. According to Nicholas J. Patterson:

> Technology is not a source of unemployment - rather the business cycle and inflation are by far the main factors, because they are accompanied by a decline in investment in technology and by increased costs. The reason why technology increases jobs and prosperity is that automation cuts costs,

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[8]Peter McGill, "High tech tosses Japanese bosses, workers on scrap heap", Globe and Mail, 19 August 1983, p. 7

> while at the same time permitting increased production and higher wages and profits. This constitutes a source of new wealth and a demand for new products, which can be supplied by new technology. In turn, the new production and new products create new jobs.[9]

A parallel for successful productivity improvement through automation and the absorption of displaced workers in other sectors is seen in the mechanization of agriculture:

> In 1933, it took 1.1 million workers, out of a labor force of 2.7 million, to produce food and other farm output for domestic use and export. Agricultural workers accounted for 40 per cent of employment. Now farm workers number 465,000, only 4.4 per cent of a labour force of 10.5 million. Fewer than half the number of workers feeds almost four times as many people.

Economist Peter Dungan also uses the historical record as evidence that changes in employment brought about by the application of micro-electronic technology will be gradual rather than revolutionary. Charting the paths of productivity growth, output growth and unemployment over the last fifty years, he finds that there is no period of simultaneous high unemployment and high productivity growth. He is a qualified optimist in his expectations for the future:

> Of course, it cannot be said that unemployment will not be a concern in the 1980s. There could be significant unemployment in situations of chronic low demand engineered by monetary and fiscal policy in face of intractable inflation, excessive fear of deficits, or mis-timed efforts at restraint. But, if high unemployment should result from high productivity growth, it

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[9]Nicholas J. Patterson, "High tech means higher employment", Globe and Mail, 22 July 1983, p. 7.

would be a break from the last fifty years of historical experience.[10]

3.0 OVERVIEWS OF CURRENT RESEARCH

Several reviews and summaries of reports on the impacts of technology have been published. Analysts who have examined evidence for both the optimistic and pessimistic scenarios remark on the lack of convincing quantitative analysis of the overall impact of changing technology. Although the long-term outlook is uncertain, there is still a need for continuing research, and for measures to ease the transition for those categories of workers who will certainly be affected.

The Sleigh Report[11] from the United Kingdom (1979) considers the implications of new technology for the British manufacturing and service sectors, and concludes that despite inevitable shifts in employment, the overall impact on employment "is virtually impossible to gauge." According to Sleigh and his colleagues, past empirical work suggests that, in the long run, technological change has been beneficial to both output and employment. The report identifies some methodological problems in both optimistic and pessimistic forecasts of employment outcomes. For example, the models used tend to ignore the indirect macroeconomic effects of the new technology, the interrelationships between sectors, and the speed of diffusion of new technology (p. 106).

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[10] "Mass Unemployment and Technological Change in the 1980s--What are the Prospects?", Labour Relations News, (University of Toronto, Sept. 83)

[11] Jonathan Sleigh et al, The Manpower Implications of Microelectronic Technology (London, 1979).

The impact of microelectronic technology will be "gradual rather than revolutionary", and the existing infrastructure of government policy and provision can cope with problems that may occur (p. 109).

In 1979, Zavis Zeman of the Institute for Research on Public Policy assessed a wide range of reports on the employment impacts of microtechnology. Like the Sleigh Committee, Zeman concludes that the available evidence does not fully support either the optimistic or the pessimistic scenario. He points out the biases and erroneous assumptions that are used to augment weak empirical evidence.

> The labour-related spokesmen demonstrate a tendency to stress the negatives, while the management-related researchers and authors attempt to minimize them and to stress the positive contributions of the new technology. To repeat, the nature of the debate is above all political and should be judged as such.[12]

According to Zeman, the ultra-pessimistic forecasts are unrealistic, in part because of methodological errors such as "excessive extrapolation from a case in a single or several companies to a whole sector or economy; ignoring interactions among sectors of economy, ignoring social resistance to technological change; bottlenecks to adaptation caused by shortages of skilled workers or capital, and ignoring the differences between the most and least progressive companies" (pp. 34-36).

He says that, so far, attempts to analyze the issue quantitatively have not been satisfactory (p. 38). There is no consensus in the literature

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[12] The Impacts of Computer/Communications on Employment in Canada: An Overview of Current OECD Debates (Montreal, 1979), p. 32.

on the net employment impact for the whole economy. Since no one really knows what the net effect will be, "public debate is needed on the important issue of who should bear the brunt of technological change" (p. 43).

Zeman repeatedly emphasizes that the evidence is not conclusive one way or the other. Because of this, both optimists and pessimists should "hedge their bets", and further monitoring of the issue on a continuous basis is essential. More factual information should be gathered, especially case studies at the sectoral and company level (pp. 48-50).

C.A. Jecchinis, in a report for the Ontario Manpower Commission, also surveys the current literature, and supports Zeman's general conclusions. Although the employment impact of microelectronics will be gradual rather than sudden, the absence of "appropriate government and business policies cannot but aggravate the already critical unemployment situation, contribute to further industrial conflict, and offset the positive contributions that microelectronics applications can make to increased productivity."[13]

Similarly, a 1980 workshop sponsored by the Science Council of Canada Committee on Computers and Communication could reach no consensus on the macro employment effects of microelectronics. Workshop participants did see that some structural changes were inevitable, perhaps producing a great deal of unemployment. They suggested that in the short term,

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[13] The Impact of Microelectronic Technology on Employment: A Survey of Current Research Studies in Selected West European Countries (Toronto, 1980), p. 71.

"most research should not be looking into the overall employment effects, but rather into the labour displacement effects; what kind of jobs will we have, where will they be located geographically, in which sectors, and who is going to be affected by them?"[14]

4.0 EDUCATIONAL REQUIREMENTS FOR FUTURE LABOUR MARKETS

Recurrent education and retraining are obvious solutions to anticipated structural employment problems. Whether education alone, or even in combination with other conventional measures, will be adequate to deal with the problems depends on the severity of displacement foreseen. If the long-term scenario of the pessimists is realized, the problem will not simply be one of skill mismatches, but of sharing a limited number of jobs among a large number of potential workers, most of whom might be very well-qualified by any standard. We will need to change our attitudes toward work, if, with the aid of machines, fewer workers are able to produce all the goods and services that the economy requires. Measures to share the existing work will have to be considered, such as reducing the work day or work week, longer vacations, early retirement, and sabbaticals or skill development leave for most of the labour force. Education for leisure may become as important as advanced technical and scientific education for work, as Jenkins and Sherman suggest in The Collapse of Work:

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[14] The Impact of the Microelectronics Revolution on Work and Working (Ottawa, 1980), p. 21.

> Finally and crucially provision is required for life-long education. People should be enabled, if they wish, to use education and knowledge as an end in itself, to treat it as a leisure activity and at all levels. The unemployed should have priority in access to all educational establishments; they should be free to make major changes in their careers at least twice in a lifetime and to be provided with the necessary resources. (p. 169)

The impact of technology on skill requirements has usually been considered either in relation to particular groups, such as clerical workers, or in relation to industrial demands, to ensure that enough highly qualified personnel are available. The latter concern appears, for example, in the Science Council's criticism of a lack of coordinated effort among government, industry and the universities to ensure that Canada has a share in the expected productivity benefits of technological innovation:

> Despite the great demand for Canadian workers trained to design and build hardware and to develop systems and applications software associated with the new technologies, provincial governments have failed to assess realistically the urgency of this problem and make the necessary realignments of priorities. Rigidities in university funding mechanisms should be removed so that highly-qualified people will be available in sufficient numbers. Both federal and provincial governments should develop capital and operating programs that will increase funding for education in this vital area. An important role also exists for industry, both to make clear its projected personnel needs (expected to be critical by the mid-eighties) and to develop new in-house training programs, perhaps modeled on the successful apprenticeship programs in Western Europe.[15] [emphasis in original]

The provision of highly qualified personnel is of course the most obvious role of the universities in preparing for the smooth transition

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[15] Planning Now for an Information Society: Tomorrow is Too Late (Ottawa, March 1982).

to an age of microtechnology. The Ontario Microelectronics Task Force recommends that the provincial government allocate funding on a priority basis to increase the supply of highly skilled personnel, since shortages of electrical and electronic engineers, experienced computer specialists and engineering technicians and technologists may be a "major inhibitor to the development of industry and to the diffusion of microelectronics."[16] In the United States, there have been similar calls for increased investment in human capital in order to retain a competitive position in high technology development and applications. Falling high school standards and shortages of qualified mathematics and science teachers in the high schools, as well as shortages of engineers and computer scientists, are seen as serious impediments to the development of information-based industries.[17]

It is clear that the good jobs of the future will require more scientific knowledge and higher technical skills, and that economic growth based on technological advances depends on having adequate numbers of workers with the right skills ready at the right time. However, it is less certain that this kind of training is required of the entire labour force.

Henry Levin and Russell Rumberger of Stanford University question the recent emphasis of government and business leaders on providing

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[16] Microelectronics: Report of the Task Force to the Government of Ontario (Toronto: Ministry of Industry and Tourism, 1981), p. 9.

[17] James Botkin et al, Global Stakes: The Future of High Technology in America (Cambridge, Mass.: Ballinger, 1982).

high-technology skills.[18] This assessment of educational requirements is based on two assumptions: that future job growth will favour professional and technical level jobs requiring considerable education and sophisticated training in computer-related areas; and that high technology will upgrade the skill requirements of existing jobs. Levin and Rumberger find both assumptions are contradicted by the available evidence. Instead, the lowest skilled jobs in the American economy will vastly outnumber the high technology ones, and " the proliferation of high technology industries and their products is far more likely to reduce the skill requirements for jobs than to upgrade them" (p. 2).

These predictions are based on estimates of the U.S. Department of Labor's Bureau of Labor Statistics. Although between 1978 and 1990, the projected fastest growing job categories in terms of percentage change include several high technology areas such as data-processing-machine mechanics, computer systems analysts, and computer operators, the total number of new jobs generated in these and other high technology occupations will be vastly outweighed by employment growth in other areas. Percentages alone are misleading, for slower-growing occupations with a large employment base are expected to contribute far more jobs to the economy than the high technology occupations. The five occupations expected to produce the most new jobs are all in low skilled areas: janitors, nurses' aides, sales clerks, cashiers, and waiters and

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[18]Henry M. Levin and Russell W. Rumberger, The Educational Implications of High Technology (Stanford University: Institute for Research on Educational Finance and Governance, February 1983).

waitresses. Levin and Rumberger point out that only three or four of the "top 20" occupations in terms of total contribution to job growth require education beyond the secondary level, and teaching and nursing are the only ones requiring a college degree (pp. 4-5).

Thus, according to Levin and Rumberger, the assumption that rising skill levels for employment will require more training in mathematics, computer science and technical applications for the labor force as a whole is very questionable. Some jobs will require these skills, but the vast majority will not:

> With the exception of a relatively small number of highly specialized positions for designing and implementing high technology applications, most jobs will not require higher skill levels. Industrial shifts and technological change may require different skills, but the preponderance of persons affected by such shifts will not need more mathematics or computer science. And, for significant numbers of jobs, the skill requirements that will have to be met will be less demanding.(p. 11)

Schools should provide a strong general education, with emphasis on "analytic, expressive, communicative and computational skills as well as extensive knowledge of political, economic, social and cultural institutions (p. 12)." The ability to adapt to a changing work environment will be increasingly important, but "specific job skills can best be learned on the job" (p. 12). The educational system may need to adapt more quickly and efficiently to training needs, and may have to work more closely with industry, particularly in developing a system of recurrent education.

The possible emergence of a bimodal labour market, with a few high-skill jobs at the top, many low-skill ones at the bottom and very few in the middle has serious implications for educational planning. The service

sector will be the major source of new jobs in the future, yet two-thirds of the service jobs created since 1950 have been low-paying, high-turnover, part-time jobs. The supermarket clerk passing encoded grocery products across an optical scanner is a prime example of the deskilling affect of microtechnology in the service sector:

> In truth, no one really knows whether technology will create more interesting jobs than it destroys. Perhaps in the long run it will. But in this decade and into the next, we may be creating an expanding number of routinized jobs requiring little specific education or training. And such jobs no longer lead up to better jobs: the ladders of mobility are being removed.[19]

George Bohan observes that although our lives are being altered by high technologies, a deeper understanding of these technologies "is not a prerequisite to their use".[20] He questions popular calls for computer literacy as an important item in the educational agenda, since each new development in the computer field has tended to reduce the skill levels required to operate computers. Elsewhere it has been predicted that in the second half of the decade older technically oriented programmers will be displaced as fourth generation languages increasingly let the computer itself come up with "the more mundane programming tricks."[21] Instead, there will be demand for systems-style people who are familiar with business as well as technical problems.

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[19]Russ Edgerton, "A College Education Up to Beating the Japanese", AAHE Bulletin, June 1983, p. 5.

[20]George Bonhan, "Some Questions about Science Literacy", Change, July/August 1980, pp. 10-11.

[21]Jonathan Chevreau, Globe and Mail, 26 August 1983, p. B11.

The equitable distribution of technological gains may be a growing problem for industrial economies.[22] When production workers are replaced by machines, both the firm and consumers as a group benefit, but the loss falls mainly on the worker who is displaced. Eventually, the economy as a whole suffers because of the loss of purchasing power of formerly well-paid workers (p. 61). The shift away from the traditional manufacturing base to high technology and service industries could lead to an erosion of the middle of the labour market. The increasingly stratified job structure is seen in the microelectronics industry, where computer scientists and engineers with at least one college degree earn $30,000 a year or more, and the workers who assemble computers earn about $12,000 a year. The number of skilled technicians whose wages fall between these two extremes is surprisingly small. According to a group plant manager of an electronics plant near Boston:

> We've peaked in terms of our need for the classical technician. The machinery is more and more self-diagnosing. There's less of a judgment factor. The computer spits out an instruction to change such-and-such a component, and you do it. We can upgrade a $5-an-hour assembler to a $6- or $7-an-hour junior technician with little advanced training. A few years ago, we were recruiting skilled technicians as aggressively as we're recruiting engineers today. We're not doing it now. Organizations that train technicians should realize that they're preparing people for a smaller and smaller marketplace." (p. 66)

Other examples of the obsolescence of middle-level technical skills are cited. Many minicomputers are self-diagnosing and will tell the user

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[22]Bob Kuttner, "The Declining Middle", The Atlantic Monthly, volume 252, No 1, July 1983, pp. 60-72.

which part to replace (p. 66). The productivity of draftsmen is increased many times through the use of CAD/CAM (Computer Aided Design and Computer Aided Manufacturing), and a number of junior colleges have introduced CAD/CAM programs to retrain and upgrade draftsmen. However, an expected further advance in technology called CIM, or "computer-integrated manufacturing" will diminish the job of the CAD/CAM technician because the engineer will sit at the computer terminal and transform his specifications directly into a product (p. 67).

Public sector involvement may be needed in order to redistribute the benefits of increased productivity.

> As more and more of society's material goods are produced by fewer and fewer workers, the kind of society that results is ultimately a political choice. We can permit the owners of wealth to spend most of their earnings privately--and the service jobs will include salesclerks, waiters and open-heart surgeons--or we can tax away some of those earnings and let the service jobs include more teachers and social workers. The choice exists within a realm of public policy that is the least charted of all: the means for redistributing the fruits of productivity and automation. (p. 71)

Highly-skilled and technician level training will be most directly affected by projected changes in requirements for middle-level jobs. Recommendations for upgrading the skills of displaced workers frequently involve community-college level training for jobs that are expected to be in more demand. The transition from an unemployed auto-assembly worker to a systems analyst in general would be unrealistic, but to a computer maintenance technician would certainly seem possible. However, the evidence above suggests that it is just these kinds of technician level jobs that may be at risk. Programmes for retraining will have to

concentrate on generic skills, with emphasis on the ability to adapt and learn, rather than on narrow occupation-specific training.

The difficulty of accurately assessing future demand in a time of changing technology is already evident in the efforts of the federal government to prepare workers for high-technology jobs through community college programmes under the Canadian federal government's National Training Act. According to a recent newspaper article, "the less glamorous skills" in the hospitality and fast-food industries are currently in greater demand than highly skilled computer programmers and technicians.[23] Some community college administrators fear that federally-promoted high technology training is too closely related to specific dead-end jobs and that training does not include enough time on general education, such as learning how to speak and write coherently.

5.0 THE ROLE OF THE UNIVERSITIES

In all the maze of differing opinions about the impact of technology on future employment, a few threads emerge that will be relevant to university planning. First of all, there is clearly a need for more research on the long-term impacts of information and other technologies. Although quantifying future requirements for specific occupations will be difficult, it should be possible to identify more clearly the characteristics of new jobs, and the directions in which existing jobs will change. In an article provocatively titled, "Will High Technology Save Higher Education from Decline?," Michael Skolnik questions whether the

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[23]Robert Matas in Globe and Mail, 18 August 1983, "Failed Predictions: While Ottawa pushes high-tech skills, the new jobs are elsewhere."

American book Global Stakes is directly relevant to the Canadian economy and Canadian higher education. He suggests that a similar study, from a Canadian perspective, would be useful to engineering and science educators, particularly if it went further than the American book in documenting the aggregate employment and educational requirements of high technology. [24]

Research is also needed on the broader societal impacts of changing technology. How do we adapt if it indeed does turn out that only a small portion of the labour force can expect permanent full-time employment? The whole question of sharing the benefits and costs of technology needs to be considered. Such ideas as job-sharing, shorter work week, longer periods of education and earlier retirement may have be be seriously considered, if the prospect of a technological elite and a large population of the un- or underemployed is to be avoided. So far, much of the comment in this area is highly speculative, yet the problems involved are of growing importance, and touch on a number of disciplines: psychology, sociology, public administration and law, as well as economics and education.

In terms of their educational function, universities have a clear role in preparing highly-qualified personnel. Possible reductions in medium-skill jobs may lead to higher university participation rates, as young people seek to improve their competitive position in the labour market. The recent recession has reduced demand for new engineering and computer

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[24] Canadian Journal of Higher Education, Volume XIII-2 (1983), 77.

science graduates, but this is presumably temporary. Some people may question the need for major general increases in computer and science literacy, but for the kinds of jobs that university graduates seek, numeracy and some capacity to use computers are certainly minimal requirements. At the same time, general analytical and communications skills will become increasingly important, as will flexibility and the ability to learn and relearn.

It is impossible to predict whether this emphasis on the general rather than the narrowly job specific will point to improved employment prospects for the liberal arts graduate. Education, retraining, increased leisure time and social problems of adjustment may provide new employment opportunities for graduates from non-technical fields. Much depends on policy measures for coping with problems as they arise. Stuart Smith, Chairman of the Science Council of Canada, implicitly rejects Leontief's judgement about man's two-part production function (see above, p. 3) when he suggests expansion of the human-services sector:

> There is plenty of need for more human contact in our nursing homes, day care centres, hospitals, rehabilitation centres and so on. . . . The fact is that there is much value in human contact and improved life quality in these institutions (and outside them as well). This value is hard to measure, mostly because the old and chronically ill cannot afford to create a very active market for such additional services. That does not mean they are unimportant. No computer can yet substitute for mutual care and attention.[25]

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[25]Stuart L. Smith, "Business Forum", Canadian Business, October 1983, p. 133.

If ultimately governments and individuals manage to use the productivity benefits of technology in humane and constructive ways, the arts may flourish and education as an end in itself may be one of the varieties of leisure-time activity with potential for job-creation. It may be idealistic or even elitist to encourage developments of this kind, but it is probably in the interests of universities to do so.

Of more immediate and practical concern is the direction that governments will take in assessing the educational requirements of high technology. For several years there have been suggestions that the university sector is not doing enough job-related training. Community colleges and apprenticeship programmes are seen as more successful in preparing young people for the labour market. Now attention is being focused on skill development and recurrent education for adults. According to a recent federal government task force report:

> Weekend colleges, all program availability [to part-time students], on-site delivery, accelerated programs, distance delivery, career ladders, credit for previous learning, and a general market responsiveness to the learning needs of adults is becoming apparent in the Canadian community college setting. Generally this has not been the situation in the university.[26]

With rapid changes in technology and job requirements, it is obvious that job-related programmes at any level need constant adjustment if the skills they are providing are not to be soon obsolete. While we should not disparage non-university training, a case should be made for the adaptability of university graduates and the value of good general

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[26] Learning a Living in Canada, Report to the Minister of Employment and Immigration Canada by the Skill Development Leave Task Force (Ottawa, 1983), Volume I, p. 37.

education. With limited money available for both initial education and retraining, it will be tempting for governments to direct most attention to lower levels, since at least initially, programmes are less expensive and appear to be more closely tied to occupational needs. In addition, the community colleges already enjoy a reputation of being more responsive to the needs of adult and part-time learners. As retraining and upgrading become increasingly important, universities must be ready to meet changing demands. This may include offering short-term courses to update the skills of professionals who are already employed, as well as making regular programmes at all levels more accessible to part-time and mature students.

As providers of highly-qualified personnel and as centres for technical and scientific research, universities will continue to be key resources in an information-based society, whatever the long-term consequences of technological change. It is essential, however, that we maintain a broad perspective on change, and not be forced (or enticed) into narrow roles or short-term reactions.

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POOR

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